ZOOLOGIA 35: e21978
ISSN 1984-4689 (online)
zoologia.pensoft.net

SHORT COMMUNICATION

# Implanted byssal hairs on postlarval shells of *Mytilus edulis platensis* (Bivalvia: Mytilidae) from Patagonia

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*http://zoobank.org/FCB51525-88F8-496B-A150-95295405C627*

ABSTRACT. This communication describes the first records of byssal hairs on the postlarvae shells of *Mytilus edulis platensis* d'Orbigny, 1842. The postlarvae used in this study were sampled on artificial collectors used for mussel culture in San Jorge Gulf, Sudoccidental Atlantic Ocean. A general description of the hairs is made as well as an exploratory analysis of their spatial distribution on the shell surface. The presence of these byssal hairs is suggested as a criterion to differentiate *M. edulis platensis* from other mytilids.

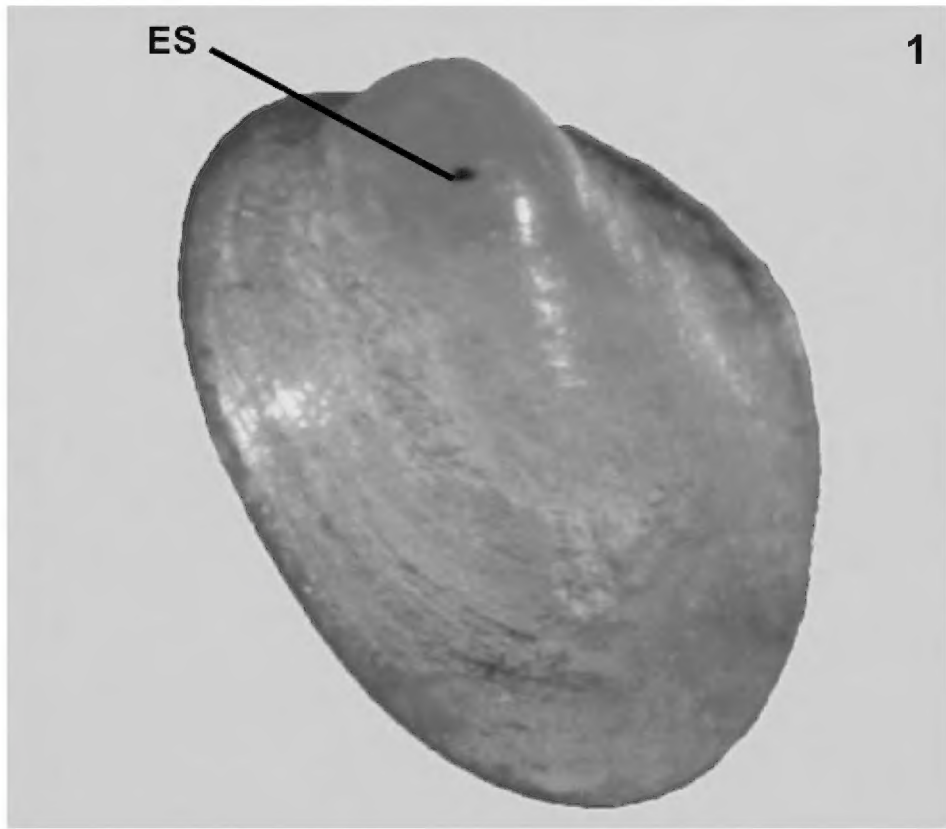
KEY WORDS. byssus threads, mussel postlarvae, spat settlement, mussel culture.

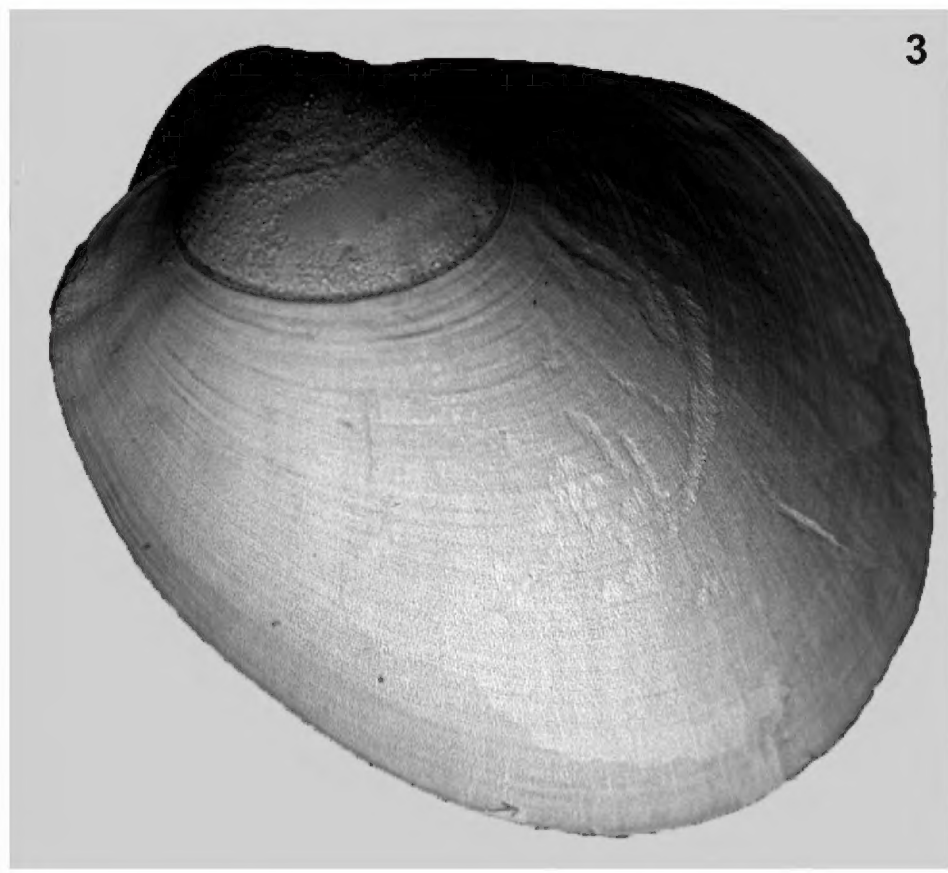
The Patagonian blue mussel, *Mytilus edulis platensis* d'Orbigny, 1842, is an important commercial bivalve in Argentina (Zaixso et al. 2015). During a collecting survey of mussel seeds for aquaculture in the Comodoro Rivadavia region (Argentina), we had to identify the youngest individuals that may compete for space with other mytilids thriving in the same area, namely *Aulacomya atra* (Molina, 1782) and *Perumytilus purpuratus* (Lamarck, 1819). The presence of plainly visible "hairs" on shells that were larger than 500 µm turned out to be very useful for the identification of the postlarvae of blue mussel. The aim of this contribution is to assess the presence and features of the self-implanted hair-like byssal threads on the shells of the spat blue mussels from Patagonia, which have not been reported on other mytilid species from this region.

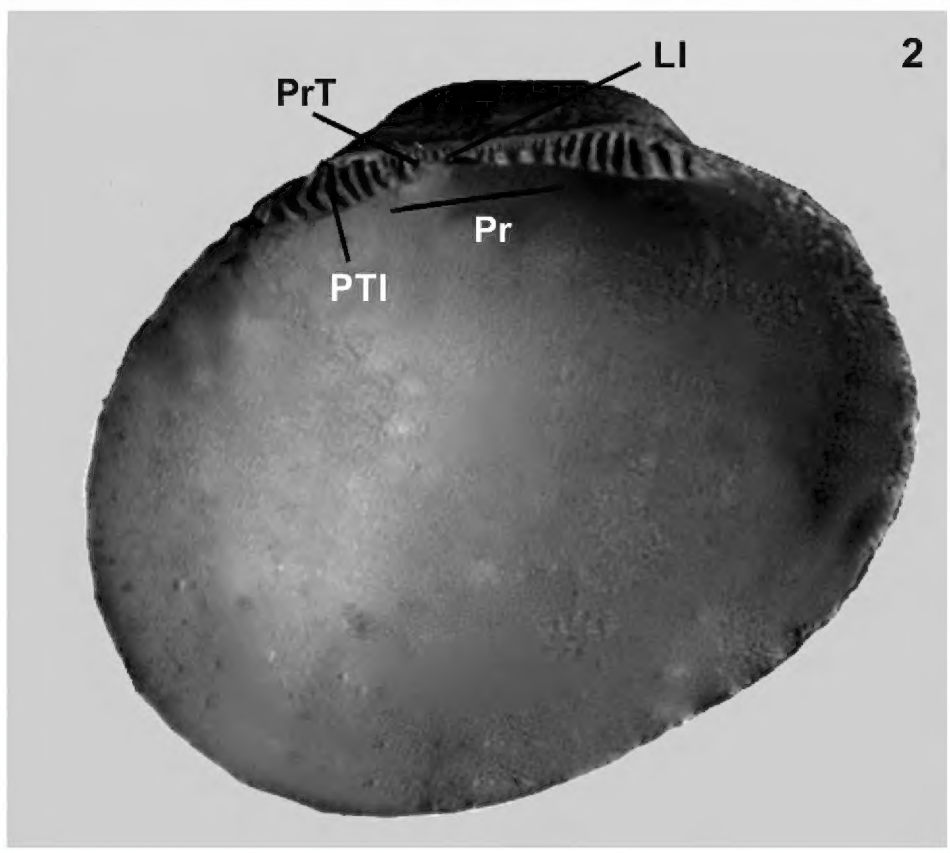
*Mytilus platensis* d'Orbigny, 1842 from Argentina and *M. chilensis* Hupé, 1856 from Chile have been long treated as different species or subspecies of *Mytilus edulis* Linnaeus, 1758 (Castellanos 1957, Dell 1964, Seed 1990). Borsa et al. (2012) confirmed that the Southern-Hemisphere *Mytilus edulis*, including the native *M. chilensis*, should be assigned subspecific rank, and that the southern South American mussels living on the coasts of both the Pacific and the Atlantic Ocean belong to a single taxon. Astorga et al. (2015) have not found genetic differences between *M. chilensis* and *M. platensis*, and for this reason they are presently considered a single subspecies under the name *M. edulis platensis* d'Orbigny, 1842, on priority grounds.

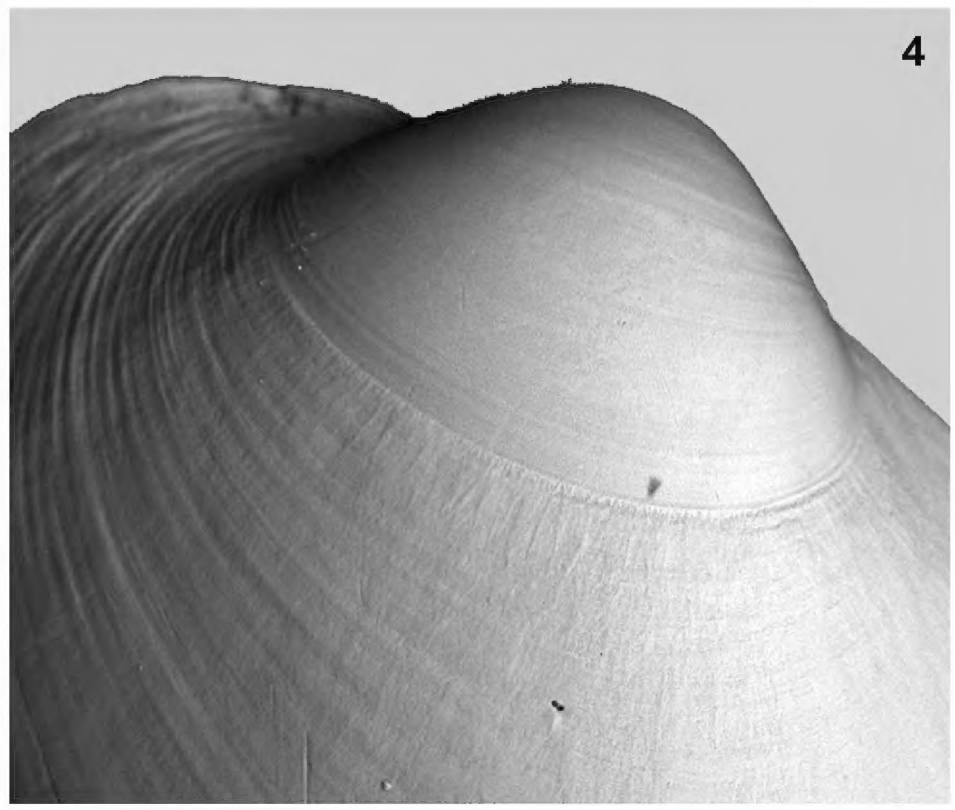
The material studied was collected from experimental substrates submerged in front of Comodoro Rivadavia (45°50'12.21"S, 67°26'3.27"W) and Belvedere beach (45°59'12.13"S, 67°33'17.45"W), on the central coast of the San Jorge gulf, Chubut province, Argentina. The area is influenced by the cold waters of the Patagonian Current, which flows along the Patagonian coast northwards from the Strait of Magellan. A branch of this current entering the north-west direction predominates in the study area. The salinity recorded during this study was quite homogeneous throughout the year, with a mean value of 34.11 ± 0.08 psu. The minimum temperature, recorded in September, was 8.1 °C and the maximum, recorded in February, was 15.8 °C. The presence of a strong tide front of seasonal permanence and variable position (Fernández et al. 2005) makes the area a biological hotspot in terms of diversity, including species that are valuable for fisheries and which breed there, particularly in the southeast and northeast extreme of the gulf. In the central costal region of the gulf, rocky shores are mainly formed by consolidated limestone and are dominated by kelp forests of *Macrocystis pyrifera* (L.) C. Agardh, 1820 (Laminariales) and their associated community.

Collectors were made of shadow mesh folded in a rope and fastened with properly tensioned seals. Each rope was 12 m long and contained three collectors at 4, 8 and 12 m away the seabed. The collectors were submerged for one month to




Figures 1–4. Postlarvae of *Mytilus edulis platensis*: (1) outer view of a postlarva 400 µm long, with an eye spot (ES) and naturally deprived of adventitious hairs; (2) inner view of a postlarval shell; (3) general view of an 850 µm long shell – a marked growth line delimits the prodissoconch II; (4) close up of the umbo of an 850 µm long shell. (LI) Larval ligament, (Pr) provinculum (hinge), (PrT) provincular or primary teeth, (PTI) posterior teeth I. Figures 2-4 are SEM micrographs; the periostracum was previously removed.

promote the production of a biofilm on their surface (Satuito et al. 1995, Qian et al. 2007), and after the second month of immersion a set of collectors was removed every month by scuba diving and replaced by a similar set, which remained submerged for another two months. The extracted collectors were frozen at -20 °C until processing. The postlarvae were picked out for identification and counted under a stereoscopic microscope after washing the samples and sieving through a 250 µm mesh. They were measured with an ocular scale under a compound microscope. Scanning electron microscopy (SEM) was used to analyse hinge and valve characters, especially on individuals less than 400 µm long; before this procedure the specimens were placed in a 5% solution of commercial bleach (sodium hypochlorite) to eliminate ligaments and tissues. Identification followed the guidelines by Ramorino and Campos (1983), assuming the identity of *M. edulis platensis* and *M. chilensis*, after the genomic results by Borsa et al. (2012) and Astorga et al. (2015).

The abundance of hairs, when present, was estimated from the apparent area of shell micrographs, and their spatial pattern was assessed by the Byth-Ripley distance method checked with a Hopkins test (Krebs 1999).

The maximum settler's abundance was recorded in the early autumn (March). The size of the settled postlarvae ranged from 260 to 1500 µm, with mean values of 860 to 900 µm in Belvedere and Comodoro Rivadavia respectively. The areas of the prodissoconch and provinculum of *M. edulis platensis* from San Jorge gulf, Argentina, were fully compatible with the description by Ramorino and Campos (1983) for the Chilean mussels under the name *M. chilensis*. Figure 1 shows a 400 µm long postlarva with no attached byssal hairs. Larger individuals had an oval prodissoconch II longer than 250 µm, low and thin provincular teeth, and posterior teeth II just hinted or absent (Figs 2–4).

Most postlarvae of *M. edulis platensis* that were larger than 450–500 µm had yellow threads of variable sizes and density on both valves. The hairy area roughly occupied the dorsal half of the valves of 800 µm long individuals (Fig. 5) and about three thirds of the surface of the largest studied postlarvae (Fig. 6), except for a marginal fringe about 50 µm wide. The bases of the hairs were usually surrounded by considerable amounts of organic and inorganic materials, forming a coat over the entire hairy area (Fig. 6). The hairs were attached to the periostracum on a broadened basis, and they were helicoidally twisted towards the gradually thinned tip (Figs 7–8).

Threads of different lengths were observed over the hairy area on an anteroposterior gradient of size, those located on the rear part of the valve were the largest. However, their spatial distribution did not differ from chance over the hairy area ($t = 0.34$, g.l. = 82, $p = 0.74$). The hairs were larger on postlarvae that had settled for a longer period of time, from a few micrometres on the youngest hairy spat up to around 20 µm on a postlarva 600 µm long, and 60–90 µm in postlarvae larger than 800 µm. Hair density was estimated in a range of 6 to 22 hairs $mm^{-2}$.

Dixon et al. (1995) described the presence of "adventitious hairs" on the spat shells of *M. edulis* from England. The size of the smallest spat bearing hairs (between 500 µm and 1 mm long) seems to be the same in Patagonia. The proportion of hairy spat varies with size in England: figure 4 in Dixon et al. (1995) shows that hairy shells represented 85% of their studied postlarvae less than 1 mm long; 60–70% of spat up to 2.5 mm, and a minority in the set of valves larger than 2.5 mm. Coincidentally, most spats larger than 500 µm collected in Patagonia were covered with hairs, and most of our 1.0–1.5 mm long postlarvae were markedly hairy. Due to the specific aim of our project, the upper bound of the available material was limited to 1.5 mm.

The shape and distribution of hairs on the spat of Patagonian mussel were similar to those of *M. edulis* from England, which Dixon et al. (1995) assumed to be of periostracal origin. However, if these hairs are pallial derivatives, then a regular, uniform distribution is expected. Our results indicated a random pattern, as an outcome of the foot activity of populating the own


Figures 5–8. Postlarvae of *Mytilus edulis platensis*: (5) an 800 µm long postlarva with the "hairy" periostracum; the eye spot is still visible; (6) a 1 mm long postlarva under SEM; (7–8) close up of adventitious hairs (SEM, 300 × and 850 × respectively).

shell surface with byssal threads. The process was described by Choo et al. (2014) for adult *Modiolus traillii* (Reeve, 1857), a mussel from Singapore bearing a coat of long hairs throughout its life cycle. They observed that the planting of a byssal hair involves a stretching motion of the foot and a pumping movement up to the completion of the attachment, after which the foot quickly retracts from the surface. This process is faster than fixing a byssus thread to the substrate. The hairs described for other mytilid mussels are probably produced by the same mechanism. In Argentina, Montalto and Rojas-Molina (2014) described such adventitious byssal hairs on the invasive freshwater mussel *Limnoperna fortunei* (Dunker, 1857), on both pre-reproductive and adult specimens.

Dixon et al. (1995) suggested that the presence of byssal hairs on the postlarvae of *Mytilus edulis* could be of taxonomical value. Regardless of their function (Board 1983, Bottjer and Carter 1980, Choo et al. 2014, Ockelmann 1983), these structures are taxonomically valuable within certain contexts. For instance, Bownes et al. (2008) used the presence of byssal hairs as a diagnostic character to distinguish the hairy postlarvae of the invasive mussel *Mytilus galloprovincialis* Lamarck, 1819 from the non-hairy posrlarvae of the indigenous mytilids *Perna perna* (Linnaeus, 1758) and *Choromytilus meridionalis* (Krauss, 1848) in South Africa. However, they have not illustrated or described those hairs properly to allow any useful comparison.

Our results confirm that the byssal hairs of 0.5 to 1.5 mm long spat of *Mytilus edulis platensis* are similar to those of the nominotypical *M. edulis edulis*, and they were a useful tool to distinguish the spat of this species from postlarvae of the other known marine mytilids in the area (*A. atra* and *P. purpuratus*), which do not display this trait.

In the Atlantic coast of Patagonia there is no evidence of the presence of the invasive mussels *M. galloprovincialis* and *Mytilus trossulus* Gould, 1850, which were recorded in southern Chile (Astorga et al. 2015, Borsa et al. 2012, Tarifeño et al. 2012). It would be of great interest to confirm whether the postlarvae of those and other species in *Mytilus* have the same kind of byssal hairs.

## ACKNOWLEDGEMENTS

We want to make a special mention to Héctor E. Zaixso who have made distinguished contribution to our careers as researchers and as a person with his support and encouragement. Tomás E. Isola and Martín A. Varisco are a fellow and a staff researcher of the Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), respectively. Néstor J. Cazzaniga is a staff researcher of the Comisión de Investigaciones Científicas de la Provincia de Buenos Aires.

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Submitted: 31 October 2017
Accepted: 21 November 2017
Available online: August 30, 2018
Editorial responsibility: Rosana M. da Rocha

**Author Contributions:** TEI, MAV and NJC contributed equally to this article.
**Competing Interests:** The authors have declared that no competing interests exist.